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THE ANNUAL EXHIBITION FOR 1874.

THE day for the opening of this year's Exhibition is now close at hand. We are glad to notice that the electrical and telegraphic world will be represented in Class 14—Scientific Inventions, and that space will be at the disposal of anyone who desires to display novel electrical inventions or apparatus. At a recent meeting of the Society of Telegraph Engineers, the Members were informed that the Council had received a letter of invitation from the Secretary of the International Exhibition to exhibit whatever scientific objects of interest they might have suitable for the purpose.

We trust that the appeal then made to Members of the Society will lead to the display of a large and varied collection of electrical objects. England may be termed the birthplace of Telegraphs. The inventions in telegraphic apparatus of all kinds, which her *savants* have constructed, improved upon, and, so far as the science extends, perfected, are in advance of the attainments of other countries; electricians of all grades should therefore do all they can to make the collection worthy of the high position this country holds in the electrical world. We should like to see a collection of all important inventions from the date of the discovery of the Science of Electricity placed side by side,—for instance, frictional machines, from the time of Hawksbee to our own; batteries, from De Luc's dry pile to the latest form; recording apparatus of all kinds, &c.

As soon as the Exhibition opens we shall give a description of all instruments and apparatus connected with the science of which this Journal is the exponent.

We learn that, as an encouragement to Art, the Council of the Society of Arts intend offering a gold and a silver medal in each class: these medals will be given for any object which, in the opinion of the Council, is deserving of notice for excellence of manufacture, or for supplying important wants in the scientific world.

ON THE ATTRACTIONS OF MAGNETS AND ELECTRIC CONDUCTORS.*

By GEORGE GORE, F.R.S.

BEING desirous of ascertaining whether, in the case of two parallel wires conveying electric currents, the attractions and repulsions were between the currents themselves or the substances conveying them, and believing this question had not been previously settled, I made the following experiment:—

I passed a powerful voltaic current through the thick copper wire of a large electro-magnet, and then divided it equally between two vertical pieces of thin platinum wire of equal diameter and length (about 6 or 7 centimetres), so as to make them equally white-hot, the two wires being attached to two horizontal cross wires of copper.

On approaching the two vertical wires symmetrically towards the vertical face of one pole of the horizontally placed magnet, and at equal distances from it, so that the two downward currents in them might be equally acted upon by the downward and upward portions respectively of the currents which circulated round the magnet-pole, the one was strongly bent towards and the other from the pole, as was, of course, expected; but not the least sign of alteration of relative temperature of the two wires could be perceived, thereby proving that not even a small proportion of the current was repulsed from the repelled wire, or drawn into the attracted one, as would have occurred had the attraction and repulsion taken place, even to a moderate degree, between the currents themselves; and I therefore conclude that *the attractions and repulsions of electric conductors are not exerted between the currents themselves, but between the substances conveying them.*

Some important consequences appear to flow from this conclusion, especially when it is considered in connection with Ampère's theory of magnetism, and with the molecular changes produced in bodies generally by electric currents and by magnetism.

As every molecular disturbance produces an electric alteration in bodies, so, conversely, the discoveries of numerous investigators have shown that every electric current passing near or through a substance produces a molecular change, which is rendered manifest in all metals, liquid conductors, and even in the voltaic arc, by the development of sounds, especially if the substances are under the influence of two currents at right angles to each other. In iron it is conspicuously shown also by electro-torsion, a phenomenon I have found and recently made known in a paper read before the Royal Society.

Numerous facts also support the conclusion that the molecular changes referred to last as long as the current. De la Rive has shown that a rod of iron, either transmitting or encircled by an electric current, emits, as long as the current lasts, a different sound when struck, and we know it also exhibits magnetism. The peculiar optical properties of glass and other bodies, with regard to polarised light, discovered by Faraday, also continue as long as the current. A rod of iron also remains twisted as long as it transmits and is encircled by electric currents; and in steel and iron the molecular change (like magnetism) partly remains after the currents cease, and enables the bar to remain twisted.

That the peculiar molecular structure produced in bodies generally by the action of electric currents also possesses a definite direction with regard to that of the current, is shown by the rigidly definite direction of action of magnetised glass and many other transparent bodies upon polarised light; also by the difference of conductivity for heat and for electricity in a plate of iron parallel or transverse to electric currents; by the stratified character of electric discharges in rarefied gases, and the action of electric currents upon it; and especially by the phenomenon of electro-torsion. In the latter example an upward current produces a reverse direction of twist to a downward one, and a right-handed current developes an opposite torsion to a left-handed one; and the two latter are each internally different from the former. As each of these four torsions is an outward manifestation of the collective result of internal molecular disturbance, and pos-

* Read before the Royal Society March 14, 1874.

sesses different properties, these four cases prove the existence of four distinct molecular movements and four corresponding directions of structure; and the phenomena altogether are of the most rigidly definite character.

As an electric current imparts a definite direction of molecular structure to bodies, and as the attractions and repulsions of electric wires are between the wires themselves, and not between the currents, repulsion instead of attraction must be due to *difference of direction of structure* produced by difference of direction of the currents.

Although the Ampèrean theory has rendered immense service to magnetic science, and agrees admirably with all the phenomena of electro-magnetic attraction, repulsion, and motion, it is in some respects defective; it assumes that magnetism is due to innumerable little electric currents continually circulating in one uniform direction round the molecules of the iron; but there is no known instance of electric currents being maintained without the consumption of power, and in magnets there is no source of power; electric currents also generate heat, but a magnet is not a heated body.

If, however, we substitute the view that the phenomena of attraction and repulsion of magnets are due, not to continuously circulating electric currents, but (as in electric wires) to definite directions of molecular structure, such as is shown by the phenomena of electro-torsion to really exist in them, the theory becomes more perfect. It would also agree with the fact that iron and steel have the power of retaining both magnetism and the electro-torsional state after the currents or other causes producing them have ceased.

According to this view, a magnet, like a spring, is not a source of power, but only an arrangement for storing it up, the power being retained by some internal disposition of its particles acting like a "ratchet," and termed "coercive power." The fact that a magnet becomes warm when its variations of magnetism are great and rapidly repeated, does not contradict this view, because we know it has then, like any other conductor of electricity, electric currents induced in it, and these develope heat by conduction-resistance.

According also to this view, any method which will produce the requisite direction of structure in a body will impart to it the capacity of being acted upon by a magnet; and any substance, ferruginous or not, which possesses that structure has that capacity; and in accordance with this we find that a crystal of cyanite (a silicate of alumina) possesses the property, whilst freely suspended, of pointing north and south by the directive influence of terrestrial magnetism, and one of stannite (oxide of tin) points east and west under the same conditions.

THE THEORY OF MAGNETIC FORCES.

This forms the subject of a memoir recently communicated to the Imperial Academy of Sciences, Vienna, by M. Stefan. The work consists of three parts.

In the first, "On Calculation of the Magnetic Forces of Electric Currents," it is shown that the equivalence between forces obtained from magnets and those from systems of electric currents is complete, not only (as is known) in the exterior, but also in the interior space, and that the action of a magnet on a point lying beyond its elements must be distinguished from its action on one found within these. A simple rule is given for calculation of electro-magnetic forces; and it is specially remarked that the interior of a ball, round which currents circulate in parallel circles, affords a homogeneous magnetic field; that the same property belongs also to an ellipsoid; and such systems of currents afford galvanometer and magnetisation spirals of constant force.

In the second part, "On the Action of a Magnet on an Interior Point," this problem, already touched upon in the first part, is handled more fully. It is shown that the action of a magnet on an interior point is not perfectly determined by the magnetic potential; that, besides the forces given by this potential, there are others operative, various in direction and strength, according as the point affected is within or without a molecule of the magnet. These forces are dependent on the form and position of the molecule, and of such a nature that the sum of their work, in a finite path, is *nil*. Only where the magnetism of the molecules arises from electric currents, the latter is generally not the case; and the principle of conservation of work requires the appearance of induction currents.

The third part has for subject, the "Theory of Magnetic Induction." The principle found in the second part as to the action of a magnet on a point in the interior of one of its molecules, serves here as basis. This principle being assumed, the general equations of the theory of magnetic induction, and the theory (identical with this) of dielectric polarisation, can be directly written; and, with aid of some principles ascertained in the first part, certain problems as to the magnetisation of a ball, an ellipsoid, a ring, can be solved without further calculation. Several series of experiments are then discussed, from which it appears that all kinds of iron and steel permit of the same maximum of magnetisation, that the resistance of iron and nickel to magnetisation is at first very great, then decreases to a minimum value, which is reached when the induced magnetic moment is become a third of its maximum; and thenceforth the resistance again increases to an infinite extent. From these data, and some general considerations, a formula is deduced for the magnetic molecular force, which is found to agree well with experience.

THE HISTORICAL DEPARTMENT OF THE GERMAN TELEGRAPH EXHIBITION AT VIENNA IN 1873.*

(Concluded from p. 103).

Having thus noticed the various groups of telegraphs in the stricter sense of the term, there remain those apparatuses which belong (almost independently of the choice of a particular telegraph), to the completion and equipping of stations; and, after glancing at these, we may briefly refer to the sources of electricity and the telegraph lines. Before doing so, however, a few words about automatic quick writers.

So long as, in telegraphy, the sending of a current is in the hands of a clerk, the regularity and correctness of the signs, as also the rapidity of

* Abstract of a paper by Dr. Zetzsche in the *Internationale Ausstellungs-Zeitung*.

signalling, must depend on the expertness and practice of the operator; whereas a machine adapted for sending of currents would work quite regularly and with a rapidity which would find its limit only in the capability of the line to receive currents. The pointer telegraphs are mostly furnished with automatic transmitters; in the Morse writing, on the other hand, manual work still preponderates, and the historical department contains a rich collection of Morse keys, from one of the year 1850 down to the key now commonly used since 1871; also Siemens's key for induction currents (1855), his submarine key (1857), and various keys with change of battery. Morse attempted an automatic transmission of current even in his first telegraph, causing the telegrams, represented by a succession of long and short metallic pieces (types) fixed in a plate, to pass under a contact lever, which, on being raised by the types, closed the circuit. But this arrangement cost too much time, and the electro-magnets did not follow with sufficient quickness and certainty. Thereafter Bain (1846) cut out the Morse points and lines with a sort of pincers in a strip of paper, which was then wound round a metallic cylinder connected with a battery, while a spring or roller connected with the circuit came into contact with the metal at the perforated parts, and by this means the Morse writing was reproduced, electro-chemically, at the receiving station. In 1852 this mode of telegraphy was in use, some time between Liverpool and Manchester. More successful had Siemens been with his quick writer (already noticed), which was constructed at first for the Russian state telegraph lines; and which, like his relay apparatus, possesses oscillating magnets. Besides these two apparatuses, there is exhibited the perforator, with three keys, for piercing the strips, and the signalling instrument, in which a steel style passes through the holes of the strip. From 1856 Siemens and Halske endeavoured to solve the problem more thoroughly, by means of magneto-electric induction currents, in a permanent polarised electro-magnet system, and they supplied (1857) the Sardinia-Malta-Corfu line with such apparatus. The most recent progress in the Siemens quick writers for perforated paper strips, as used on the India lines made in 1868, is shown in the equipment of one line. The perforating key pierces the strip, which is carried by a small roller furnished with a series of guiding holes, and at the other end of the line a polarised ink writer is attached as receiving apparatus. If magneto-induction currents are used in place of battery currents, the signalling instrument arranged for the purpose allows only the currents required for the Morse signals to pass into the line. Meanwhile, Siemens had tried another way with the type quick writer patented in 1862; types which represented entire Morse letters (later only lines, points, and intervals) were set in a frame and passed under a contact lever, the alternating currents (at first magneto-induction, afterwards galvanic) being thus sent through the line to a polarised ink writer at the receiving station. The type setting and distributing machine constructed by Siemens is unfortunately not exhibited. It is still more to be regretted that the Wheatstone automatic apparatus, patented in 1858 (and employing also perforated strips) along with its ingenious transmitting instrument for alternating currents, and especially its most recent arrangement for compensating currents, has not been shown. The three newest quick writers appear in Siemens and Halske's collections; in all three the preparing apparatus is connected with the writer proper; they are furnished with finger boards, and require neither types nor a perforated strip. Siemens's quick writer gives Steinheil writing; that of Hefner-Alteneck (1872) Morse writing. The quick printer (of Siemens, 1873) prints the telegram in type, writing much more quickly than Hughes's; there is a type-wheel, which, through two escapements, is brought back to the nil point after each impression, while opposite currents of equal duration are used, which have proved so specially serviceable in submarine lines.

The historical exhibition has a rich collection of relays of various construction. Near the oldest of them (1849), with straight armature-lever, are shown the Hanoverian (1850) with bent lever, the Siemens's box relay (1851), and a whole series of the most various polarised relays; the relays of Nottebohm and Borggreve (both of 1857, with horizontal electro-magnet); a relay with electro-magnetic core, which can be varied according to the strength of current; and Siemens's relay with two electro-magnets and two armatures for translation in lines, with alternating currents.

There is also no lack of alarums. To the oldest (Sömmering's) are added—Schilling's apparatuses, the Kramer alarum for intermediate stations (1849), Siemens's intermediate alarum (1850), and the post-alarums of Borggreve (1857) for currents of determinate direction.

It is to be regretted that the history of the origin of translators is not clearly shown in the exhibition, and especially that the oldest Siemens's translator for pointer telegraphs, and the oldest Morse translators are absent.

A large number of lightning dischargers are exhibited; the oldest of these (that of Steinheil's, 1846, being absent) is a plate discharger of Siemens, employed in 1848 between Eisenach and Frankfort, and consisting of three plates, the middle one connected with the earth. Then follow, in order of age, four of those used by Siemens in the years 1850 to 1853; the wire-roll lightning discharger; the wire discharger with metallic support; the point discharger, in which there are plates opposite the metallic points, and the ball and point discharger, whose plates end above in balls, while each point stands opposite another. After Siemens's vacuum dischargers (1852) come the Nottebohm separating dischargers, in the forms used before and after 1857, while the point dischargers, similar to these, are not exhibited. Lastly we have the recent plate dischargers of Elsasser (1866 and 1869). There is also a discharger specially meant for telegraph lines, consisting of two metallic cylinders, one inserted in the other; the bottom being separated by a piece of wood (which has been boiled in oil) 3 centimetres thick.

Among commutators one misses the old clamp-commutator. Along with the bar commutator used since 1854, are shown three peg-commutators of Nottebohm, as these were used till 1857, and a series of peg and bar commutators by Borggreve and others, still in use, for the various branches of telegraph service, among others the testing commutator of Elsasser (1866).

Of rheostats or resistances there are only exhibited a mile resistance, in box form, by Siemens, in 1854; a bar rheostat with resistances of 1 to 50 miles of iron wire 2·1 lines in diameter (1857), and the graphite resistances used since 1865, at intermediate stations, for regulation of the line resistances. The latter consists of powdered graphite pressed in glass tubes, and giving a resistance of 500 to 2500 Siemens's units.

Galvanoscopes are exhibited only in their most recent forms, viz., those in use since 1869 and 1871 (after Varley, 1857), and the hair-needle galvanoscope of Siemens (1869).

As sources of electricity in telegraphy, either galvanic batteries or inductors may be used. Of batteries, the historical department shows only that of Siemens (1849), with zinc copper elements. Recent batteries have been exhibited by various German, Austrian, and French makers in their respective

departments. Of inductors may be noticed, besides the Steinheil and Stöhrer apparatuses, the magneto-inductor with 28 pairs of lamellæ, which Siemens constructed in 1850 for alarum apparatuses; the magneto inductor of Siemens (1850) for blasting charges in mines through glowing steel wires; and two electric inductors of Siemens (1855), one of which, with few elements, produces induction currents of the second order, changes them into currents with the same direction, and utilises them in Morse writing in long lines; while the other produces Morse writing with alternating currents and polarised relays.

Along the walls of the hall before the Annexé, there are inserted a number of wooden and iron posts, on which may be studied the various constructions of overland telegraph lines. Sometimes we have simple posts, sometimes double stands, double rods, and they bear various kinds of insulators. Several of these posts show the arrangements for tightening the lines. Other posts exhibit the passage of an overland line into an underground; and a tunnel box shows the connection of the cable passing through the tunnel with the overland lines. Lastly there are shown connections of lines at the stations; both the older (to 1867), and the more recent. This part is supplemented by some Bavarian rods and wire connections in the Annexé itself, and here also are the various tools and testing galvanometers, &c., used in examination of overland and underground lines. Iron telegraph posts of the newest kind are exhibited by France in the Gallery 5B, and by Siemens and Halske, in Gallery 8A of the Palace of Industry. The historical department contains no underground or submarine lines; but quite in the neighbourhood are to be seen the cable tests of Felten and Guillaume, in Cologne, and of Siemens and Halske from the factory at Woolwich. On the other hand, the department contains an exhibit with which we will here close our survey (merely glancing at the interesting maps which show the development of the German Telegraphic System in the years 1854, 1860, 1866, and 1872, and also a table which graphically represents the development of telegraph traffic and its means, in Germany, from 1854 to 1872). This is the first gutta-percha press for furnishing lines with a sheath of gutta-percha without suture; it is constructed in model by Siemens, and was handed over by him to Fonrobert and Pruckner, in Berlin. With machines formed after this model were furnished the cables for the underground lines laid in Germany and Russia, from 1847 to 1851, and they are now used for the covering of all submarine lines.

Errata.—Dr. Zetzche requests us to make the following corrections to former parts of this article:—Page 102, line 19 from top, *for* the latest *read* the oldest; line 8 from bottom, *for* are *read* could be. Page 103, line 9 from top, *for* style writer *read* translation's style writer; line 33 from top, *for* Dizner *read* Dizney; line 42 from top, *for* 1834 *read* 1854.

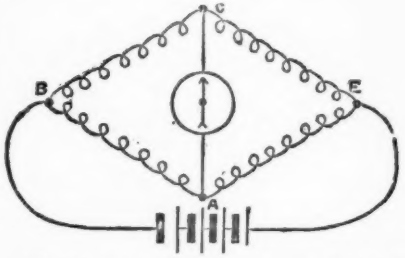
Students' Column.

Resistances and their Measurement.—By H. R. Kempe.

VIII.—*The Wheatstone Bridge.*—

The theoretical arrangement of the Wheatstone Bridge, or balance, is shown in Fig. 10. It consists of four resistances AB, BC, CE, and EA, arranged in the form of a parallelogram, a battery occupying the place of one, and a galvanometer the place of the other, diameter. When the four resistances are so adjusted that equilibrium is produced, that is to say, when no current passes through the galvanometer, then these resistances bear a certain relation to one another. This relation may be thus determined: When equilibrium is produced, the points A and C have the same potential; the galvanometer may, therefore, be removed without altering the intensities in the remaining parts of the Bridge, and, further, we

Fig. 10.



may join the points A and C without affecting the intensities. Let us first suppose the points A and C to be separated; then the joint resistance given by the four resistances between the points B and E will be—

$$\frac{(BC+CE)\,(AB+EA)}{BC+CE+AB+EA}$$

If, now, we join A and C, the resistance may be written—

$$\frac{BC.AB}{BC+AB}+\frac{CE.EA}{CE+EA}$$

which is equal to the former expression, that is—

$$\frac{(BC+CE)\,(AB+EA)}{BC+CE+AB+EA}=\frac{BC.AB}{BC+AB}+\frac{CE.EA}{CE+EA}$$

By multiplying up and simplifying, we get—

$$2BC.AB.CE.EA=(BC.AB)^2+(CE.EA)^2,$$

from which—

$$\frac{BC}{AB}=\frac{CE}{EA}$$

If, now, three of the quantities in this equation are known, the fourth can be determined; thus—

$$EA=CE\frac{AB}{BC}$$

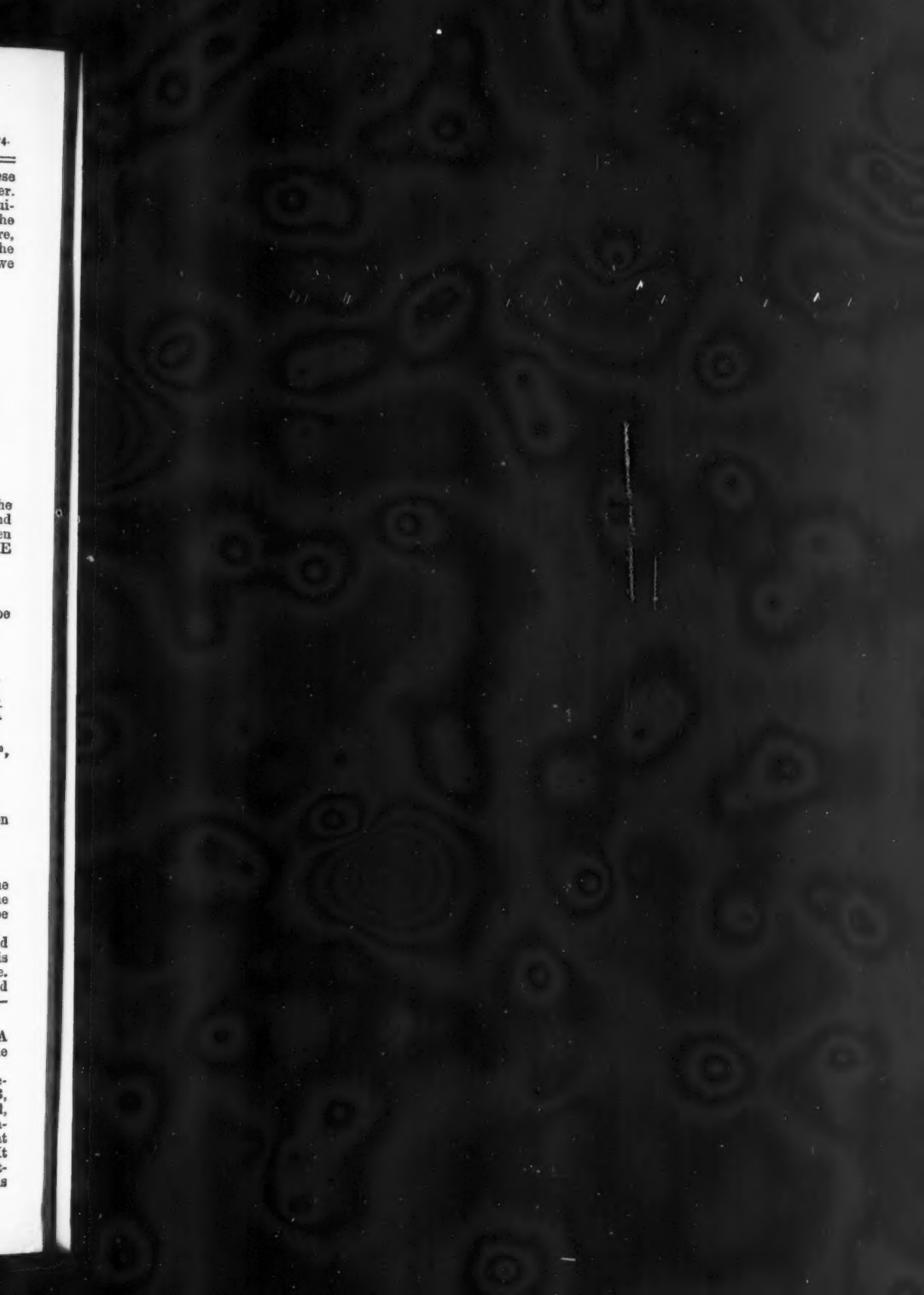
In the most general form of bridge, two of the resistances are fixed, and a third is adjustable, the fourth being the resistance whose value is to be determined.

As a rule, we should make AB and BC the fixed resistances, CE the resistance whose value it is required to find, and AE the adjustable resistance. In the simplest method of measuring we should make AB and BC of equal value, in which case—

$$EA=CE,$$

That is to say, the resistance which is between A and E when equilibrium is produced gives the value of CE, the unknown resistance.

It is absolutely necessary that there be some resistance between B and C, and between A and B, for otherwise the galvanometer is short-circuited, and equilibrium, as far as the galvanometer is concerned, will be always produced, no matter what resistances we have in the other two branches. It may perhaps be asked, what are the best resistances to employ for BC and AB. This depends



upon the resistance of the galvanometer used, and also upon the value of the resistance being measured. Of course in the majority of cases we should be unable to make a choice, as we do not know what the value of the resistance to be measured is likely to turn out. In some cases, however, the object in view is to determine *exactly* the value of some resistance whose *approximate* value is known. We may in this case employ certain definite resistances in A B and B C with advantage, as we may thereby make the galvanometer as sensitive as possible. As a general rule, it may be stated that the value of the resistances together should not be much less nor much greater than the resistance of the galvanometer. The rule for a maximum of sensitiveness, when equilibrium is very nearly produced, is that the resistance of the galvanometer should be equal to the joint resistance of the resistances on either side of it, or that—

$$G=\frac{(AB+BC)\,(CE+EA)}{AB+BC+CE+EA}$$

or, when A B and B C are equal (in which case C E and E A will also be equal), then—

$$G=2\frac{AB\,.\,EA}{AB+EA}$$

As we cannot adjust our galvanometer resistance, our aim is to find what A B should be. From the above—

$$CB \text{ and } AB=\frac{GE\,.\,A}{2EA-G}$$

Example.—In measuring the exact value of a resistance which we knew to be about 300, we employed a galvanometer whose resistance was 150 ohms; what would be the best resistances to employ in the branches A B and C B, supposing that they were equal?

$$CB \text{ and } AB=\frac{150\times300}{2\times300-150}=100.$$

Besides using equal resistances in A B and B C, we can make one of the two to be 10 or 100 times as great as the other, or, in fact, any multiple of it we like, but multiples of 10 are those most commonly used. If, when we are measuring a resistance C E, we make A B 10 times as large as B C, then every unit of resistance in A E represents $\frac{1}{10}$th of a unit in C E, for in this case—

$$CE=\frac{AE}{10}$$

We can, therefore, by this device determine the value of a resistance to an accuracy of $\frac{1}{10}$th of a unit, although A E is adjustable only to units. In like manner, if we make A B 100 times as large as B C, then every unit of resistance in A E represents $\frac{1}{100}$th of a unit in C E; for in this case—

$$CE=\frac{AE}{100}$$

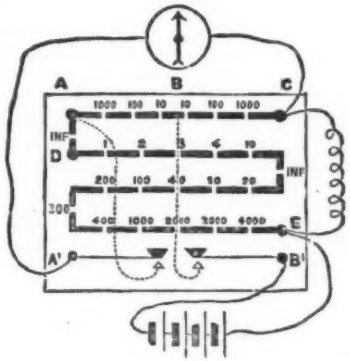
and we can thus determine the value of a resistance to an accuracy of $\frac{1}{100}$th of a unit.

In the first case, however, we cannot measure a resistance whose value is greater than $\frac{1}{10}$th of the total resistance we can insert in A E, and in the second case we cannot measure a resistance greater than $\frac{1}{100}$th of the total resistance in A E.

If, now, we wish to measure a resistance which is greater than the total resistance we can insert in A E, we must make B C larger than A B. If B C be made 10 times as great as A B, we can then measure any resistance which is not greater than 10 times the resistance we can insert in E A; but as in this case 1 unit in E A represents 10 units in C E, we can only be certain of the value of C E within 10 units. In like manner, if we make B C 100 times as great as A B we can measure any resistance which is not greater than 100 times E A, but we can only determine its value within 100 units.

The practical method of joining up the bridge is shown in Fig. 11. When the connections are made,

Fig. 11.



and the proper plugs removed from A B and B, the *right* hand key must be pressed down so as to put on the battery current. Plugs are now removed from E A until we have inserted a resistance, as near as we can guess, equal to the resistance we are going to measure. The left hand key is now pressed down, plugs being removed or shifted from between E and A until no movement of the galvanometer needle is produced upon raising and depressing the left hand key. If the galvanometer used is a very sensitive one, with a filar suspension, the left hand key must not, at first, be pressed firmly down, but only snapped down sharply; for otherwise, if equilibrium is not nearly produced when it is pressed down, there is danger of breaking the fibre of the galvanometer needle by the violent deflection of the needle. When, however, after repeated trials, we have nearly obtained equilibrium, then the key may be firmly depressed, and the final adjustment of plugs made.

If we know approximately what the resistance we are measuring is likely to turn out, we can calculate, in the way as before shown, what would be the best resistances to employ in A B and B C. If, however, we have no idea what the resistance is likely to be, the best thing to do is to take out, say, the 100 plugs, and then, having adjusted E A so as almost to obtain equilibrium, to change them for the 1000 or the 10 plugs, and see if the deflection is thereby increased. The plugs which give the best result being found, we can obtain exact equilibrium by finally adjusting E A, which gives the value of the resistance to be determined. We can adopt the same device when measuring, with unequal proportions, in A B and B C. Thus we can try whether 10 and 100 give a better result than 100 and 1000.

Besides the method of joining up, as shown in Fig. 11, we may also join up by placing the battery between A and C, and the galvanometer between B and E; this renders the action of the galvano-

meter more sensitive than by the common arrangement, under certain conditions. These conditions we may investigate hereafter.

When we are measuring the conductivity resistance of a wire, whose further end is not at hand, we should join one end to terminal C, put the further end to earth, and also put terminal E to earth, and measure in the usual way. It is always as well, however, when possible, to measure without using an earth, by looping two wires together at their further ends, the nearer ends being joined to terminals C and E respectively; this gives the joint conductivity of the two. Errors consequent from earth currents, or a defective earth, &c., are thereby avoided. We cannot, however, by this means obtain the conductivity resistance of each wire separately. If, however, we have three wires at hand, we can by three measurements obtain the conductivity resistance of each wire, without using an earth. This is effected as follows:—Let the three wires be numbered respectively 1, 2, and 3. First loop wires 1 and 2, and let their resistance together be R_1. Next, loop wires 1 and 3, and let their resistance together be R_2. Lastly, loop 2 and 3, and let their resistance together be R_3. Supposing the respective resistances of 1, 2, and 3 to be r_1, r_2, and r_3, we get—

$$r_1+r_2=R_1$$
$$r_1+r_3=R_2$$
$$r_2+r_3=R_3$$

Then subtracting the third equation from the second, we get—

$$r_1-r_2=R_2-R_3$$

and adding this to the first equation—

$$2r_1=R_1+R_2-R_3$$

therefore—

$$r_1=\frac{R_1+R_2-R_3}{2}$$

in like manner we shall find that—

$$r_2=\frac{R_1+R_3-R_2}{2}$$

and—

$$r_3=\frac{R_2+R_3-R_1}{2}$$

Thus for example. The conductivity resistance of each of three wires, Nos. 1, 2, and 3, was required. Nos. 1 and 2 being looped, the resistance (R_1) was found to be 300 ohms. Nos. 1 and 3 looped gave a resistance (R_2) of 400 ohms. Lastly, Nos. 2 and 3 looped gave a resistance of 500 ohms. Then—

Ohms.

Resistance (r_1) of No. 1 wire $=\frac{300+400-500}{2}=100$

Resistance (r_2) of No. 2 wire $=\frac{300+500-400}{2}=200$

Resistance (r_3) of No. 3 wire $=\frac{500+400-300}{2}=300$

By this device, then, we are enabled to eliminate all sources of error without making a greater number of measurements than would be required if we measured each wire separately, by using an earth. In taking the insulation resistance of a wire, the connections would be the same as for conductivity resistance, only the further end of the wire instead of being put to earth would be insulated.

It sometimes happens that we want to find the insulation resistance of two sections of one wire, but we can only test from one end.

A *a* B *b* C

Suppose A C to be the wire which we want tested for insulation resistance from A in two sections, A B and B C. Let *a* be the insulation resistance of the section A B, and *b* the insulation resistance of the section B C; and suppose *x* to be the insulation resistance of the whole wire from A to C, then we have—

$$x=\frac{ab}{a+b}$$

from which—

$$b=\frac{ax}{a-x}$$

All we have therefore to do, supposing we are testing from A, is first to get the end C insulated, and to measure the insulation resistance, which gives us *x*. Now get B to separate the wire at B, and to insulate his end of the section A B. Then again measure the insulation resistance, which gives us *a*, from which *b* can be calculated. For example: the insulation resistance (*x*) of the whole wire, from A to C, was found to be 6000 ohms, and from A to B (*a*) 24000 ohms required, the insulation resistance (*b*) of the section B to C—

$$b=\frac{24000\times 6000}{24000-6000}=3000 \text{ ohms.}$$

To get the conductivity resistance of one section of a wire when the resistance of the other section, and also of the whole wire is known, we have only to subtract the resistance of the one section from the resistance of the whole section. The truth of this is obvious.

(To be continued.)

PAPERS FOR JUNIOR STUDENTS.

Formulæ Analysed. By Arthur R. Granville.

IV.—The foregoing papers have discussed a few of the electrical formulæ whose calculations are based upon the resistance and conductivity of a conductor.

Before passing on to other classes of formulæ, it will perhaps be of some service to devote a few moments to the relationship existing between resistance and conductivity.

These two conditions of a conductor have been repeatedly referred to as mutually in opposition; that the one is the converse or reciprocal of the other. Consequently, since the value of conduction is represented by a fraction whose denominator is the number of ohms resistance, conductivity must increase in the same ratio that resistance decreases, and we shall eventually arrive at a value when both resistance and conductivity will be equal to unity.

Perfect conductivity may be represented by the algebraic symbol ∞, infinity, or by $\frac{1}{0}=\infty$. Such a phenomenon, however, as a substance offering no resistance to a current of electricity, is impossible; and, therefore, the sign of infinity as having any practical value is absurd. Still this expression is the final expansion of the principle previously enunciated, for, as the denominator (the resistance) decreases below unity, from 1 to 0, conductivity as continually increases above unity, from 1 to ∞.

This investigation shows, more clearly than I have elsewhere explained, why scientists make use of "*Specific* Conductivity." By it we are enabled to classify special conducting properties with conductors of various materials, and to compare their conducting powers. Without it we should

assign varying conductivities to the same material, since it is evident that the conducting power of a line depends entirely upon its length, the diameter being always the same. For example: a mile of pure copper wire, weighing 1 lb., at 60° F., has a conducting power of 0·000865, whilst that of 1 inch of the same wire, weighing 1 grain only, has the much larger conductivity of 0·001516: hence we have two conductivities for identical materials. This error (apparent only) is remedied by specific conductivity, in which 100 is arbitrarily assumed to be the perfect conductivity of pure copper, and to which that of all other metals is compared. It constitutes, indeed, a simple rule-of-three sum; care being taken that, in all comparisons of this kind, the conditions affecting the conductors are equal.

Lastly, it may be enquired, *What is resistance?* That question cannot be answered, except as a theory built upon hypotheses which have not been all satisfactorily proved. The theory generally accepted is that propounded by Faraday, who was of opinion that the phenomenon of *induction* is its origin. He considered that each atom, or particle of matter, transmits the current by induction, and that the battery electricity, on touching the wire of the cable, polarises its first atom, which becomes endowed with electricity of the + or − nature. Suppose that the wire is in contact with the copper pole of the battery, then, according to that philosopher, the portion of the first atom of the wire is affected with a − sign, whilst that side further from the battery has a + sign. This atom in turn affects the next in a similar manner, and so on the process is continued until the last atom is reached, when the flow of the current enters the earth. It is not difficult, from this description, to imagine the current as the result of a series of shocks, so rapidly succeeding each other as to impress upon the nervous senses the sensation of one continuous action.

Noad, in his "Student's Text-Book of Electricity," states that "Faraday adopts the theory of Boscovith, according to which atoms *are mere centres of forces or powers*, not particles in matter in which the powers themselves reside. In their quiescent state these centres of forces are not arranged in a polarised form, but they become so under the influence of contiguous and charged particles. The same chapter continues the following most important statement:—"When this forced or polar condition is *readily* assumed, it is *readily* destroyed, and CONDUCTION is the result. When the contiguous particles communicate their forces less readily, insulation"—more or less perfect, according to the freedom with which the contiguous particles communicate their forces—"is the consequence." From this we infer that *conduction* and *insulation* are the extremes of one phenomenon,—that in the former contiguous particles act upon one another very quickly and freely, whilst in the latter the same action occurs in the best cases in an almost insensible degree.

In the next article I purpose commencing with the examination of some of the formulæ used to determine the weight of conductors and insulators.

ERRATA.—Page 120, second column, lines 16 and 17 from the bottom, *read* "e' = current traversing the galvanometer," and "$e - e'$ = that traversing the shunt."

(To be continued).

Proceedings of Societies.

SOCIETY OF TELEGRAPH ENGINEERS.

AT the meeting of this Society held on the 11th of March, Prof. Foster, F.R.S., occupied the chair.

The first paper read was one written by Mr. J. J. FAHIE, on "*An Improved Double-Current Telegraph Key*," designed by him.—This instrument is intended to be used for signalling the Morse code through submarine cables, long land-lines, or underground wires of moderate lengths, say 500 or 600 miles. Its advantages over the double-current keys at present in use are—1st. A higher speed of signalling on long circuits—how high the author has not yet determined, but certainly not less than ten to fifteen words per cent. 2nd. The possibility of the receiving station stopping at pleasure the sending station during the transmission of a dispatch. 3rd. Its simplicity and the ease with which it can be worked, as compared (for instance) with Siemens's submarine key. 4th. The no additional cost at which the great advantage of "stopping" is effected, in comparison with the present method of compassing the same end,—viz., the automatic switch or zinc sender. This is a costly piece of apparatus, and easily gets out of adjustment, and thus causes some delay and confusion. But these are not its only drawbacks; being situated between the battery and the line, it not only adds to the electrical resistance of the latter, but, what is of more consequence, it reduces the speed of working. The author's instrument, on the other hand, will not cost more than an ordinary double-current key, and will be as little liable to get out of order. The accompanying figures exhibit a side and end view of the key. *a* (Fig. 2) is a spring contact, carrying near its free end a semicircular platinum piece of about ¼ inch diameter. It is in metallic connection with the tongue, F (Fig. 1), which is well insulated from the lever by the block of ebonite or ivory, D. This tongue is secured by a small bolt (Fig. 3), which runs freely through the insulator and is fastened at the other side by a nut and curved steel washer. It plays between the contacts C and Z, and must remain firmly in the position in which it is placed. For this reason just sufficient pressure is put upon it, by means of the nut and washer before mentioned, so that when it is touching the screw C it shall not fall, of its own weight, on to the contact Z. S is a strong spring, for drawing up the lever to the position shown in Fig. 1. It passes up through a hole in the ebonite, and is secured to the bolt. It is, of course, insulated from the lever. The other parts of the instrument need no description. Now, as to its action. First, suppose the key to be joined to a cable of (say) 200 miles. The play of the lever may in this case be reduced to half of that shown in plan. To effect this, the little screw B should be unscrewed until the spring is withdrawn to such a distance that the lever, on being depressed, should only rub against a small arc of the contact piece *a*. The contact Z and the screw B are then adjusted so that the semicircular contact-piece on side of lever (see Fig. 2) is just clear above *a* when the lever is at rest; the lever is then depressed, and the contact-piece *c* adjusted until the lever contact is just below *a*. The screw C should always be as close to the tongue F as possible. And when the key is at rest, the lever and *r*, and the tongue F and Z, should make good metallic contacts. The key is then adjusted. The copper pole of a battery of (say) ten cells is connected to C, the zinc pole of another battery of equal strength to Z, the remaining poles being to earth. The lines are connected to L, the earth to *e*, and the receiving instrument or relay to *r*. Now to send a signal the lever is depressed; as soon as it moves downwards the connection between line and relay is broken, the tongue F immediately

after leaves the zinc and goes on to the copper, and almost at the same moment the lever rubs over the spring contact *a*. While they are thus touching, a positive or copper current or wave flows out to line, and closes the distant station's polarised relay. When the lever passes below *a* the battery is cut off, and when it touches *e* the line is put to earth. On allowing the lever to rise after making the signal, the connection between line and earth is first broken, then the tongue leaves the copper and touches the zinc, and at the next instant *a* and the lever again rub together; while they are thus in contact a "zinc" flows out to line, and opens the distant relay. When

FIG. 1.

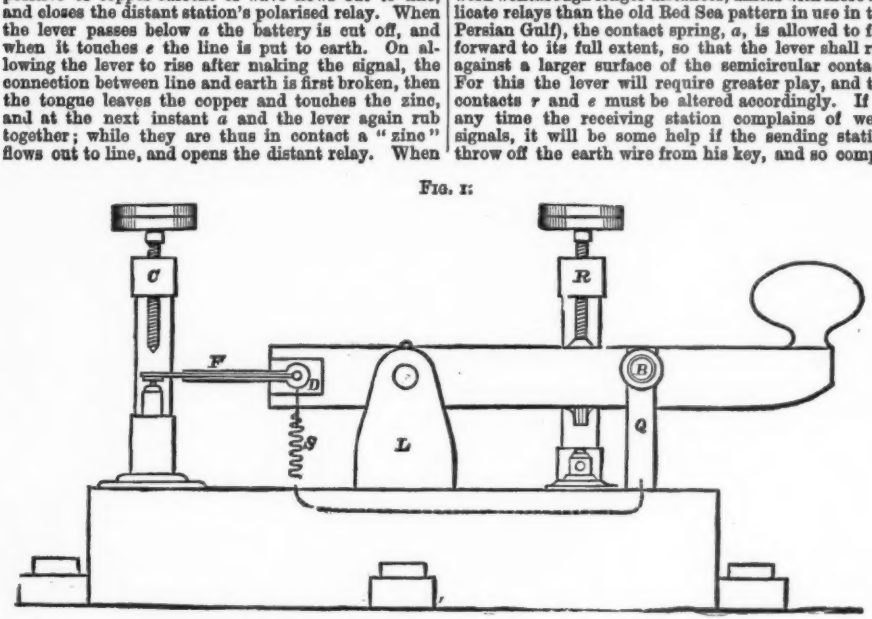


FIG. 2.

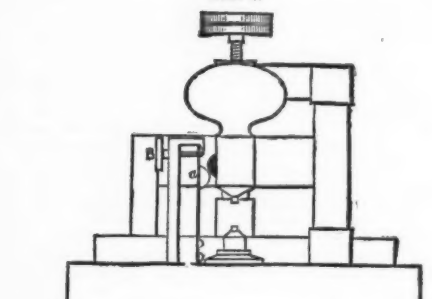
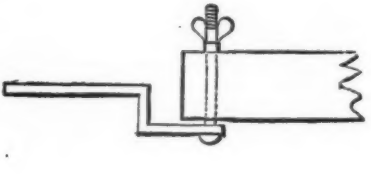


FIG. 3.



the lever passes above *a* the battery connection is severed, and immediately after the line is put to the receiving instrument. Positive and negative currents of equal strength and duration, are thus sent into the line; the injurious effects of induction operate to a much less extent, and a greater speed is possible than when signals are made by currents of unequal strength and duration (see fourth edition of Culley's "Handbook," paragraphs 468 and 469). Again, by this arrangement the line is able to discharge itself after every positive and negative wave—a great advantage. Should the distant station desire to "stop" the sender, the lever must be held for a second or two against the spring contact *a*, thus keeping a positive current on line. As soon as the sending station's lever his relay and works his "Morse," whereupon the sender stops. When working on longer lines of (say) 600 miles (and the author does not think his key would work wellthrough longer distances, unless with more delicate relays than the old Red Sea pattern in use in the Persian Gulf), the contact spring, *a*, is allowed to fall forward to its full extent, so that the lever shall rub against a larger surface of the semicircular contact. For this the lever will require greater play, and the contacts *r* and *e* must be altered accordingly. If at any time the receiving station complains of weak signals, it will be some help if the sending station throw off the earth wire from his key, and so compel returns to the contact *r*, this positive current enters the whole positive charge to go forward and act upon the distant station's relay. Indeed when working through *long or badly insulated* lines the earth wire at *e* need not be used at all. As a rule, the battery power should be increased by about one-half. The author's key may also be adjusted so as to send permanent positive currents followed by short negative currents; for this the earth wire should be removed and *e* elevated, so that the lever, when depressed, should remain in connection with *a*. A permanent positive current thus passes out to line; while the lever is returning to its normal position, after making each signal a negative current goes out. The strength or duration of this current can be altered, within certain

limits, to suit the condition of the line, by altering the play of the lever. Worked in this manner, the key will be found to give very satisfactory results on a long, well-insulated land-line. Since August, 1872, the author has, on numerous occasions, tried this key on several of the sections of the Persian Gulf cables, and has always obtained very good results on lengths under 600 miles. He is satisfied that, with a more sensitive relay than the old and heavy ones available in his department, his key will work well, with less play and through larger distances than at present.

Mr. SIEMENS said that as the new key was to work in connection with the polarised relay it had, undoubtedly, the advantage of sending the positive and negative currents of equal duration, in order that the two might neutralise each other, provided always that the motion downwards of the key was accomplished with the same velocity. If there should be a drag in pushing the key down, or in allowing it to go up, then the time of contact between the two pieces would be different on the downward journey from what it would be on the upward journey, and the balance of current in the line would be vitiated. There were some points in the construction which, perhaps, would present practical difficulty if the key left the hands of the inventor and passed into those of other operators. To begin with, the traverse of this key was very considerable, and probably there might be an objection to working a key with that traverse. Then the spring appeared to require very nice adjustment. It was to exert an elastic pressure against the point, C, or the point, Z, and yet to be sufficiently free on the point, D, to turn after its own short stroke was accomplished. Those were points of merely practical importance, which probably might be modified so that the objections might be overcome; but certainly the attempts here made to equalise the two currents by working an ordinary key appeared to be meritorious. There was a good point in the relay. It could do away with the switch, holding the two contact pieces together, and thus interrupt the working on the other side. The saving of the switch was a collateral advantage obtained by the key itself.

Mr. PHILLIPS said that it seemed that, after sending the copper current into the line, the key put the line to earth. That did not seem to occur after the zinc current was sent into the line, as far as he understood. That seemed to be a one-sided action. The Siemens key, when brought back, made an earth contact, whatever current was sent.

Mr. LATIMER CLARK said that he thought that the new key did the same.

Mr. SIEMENS said that the inventor considered E equal to earth, and used the line as earth.

Mr. G. E. PREECE (the Secretary) said that this was the only point which he noticed in the paper as open to criticism. After the sending of the copper current the earth contact was made, and the copper was discharged. Then the further depression of the key gave the zinc current which went into the line and was partly neutralised. On the conclusion of the zinc current the key went back to its relay, its normal position. The intention was that the zinc current should be neutralised, and the discharge would be little or nothing. That was his reading of the meaning, but the paper had come from the Persian Gulf, and he had not had time to communicate his queries to the author.

Mr. LATIMER CLARK asked whether the paper stated that the potential of the zinc current was less than that of the copper. He thought from the description that it was intended that they should be equal.

The CHAIRMAN said that the writer mentioned ten cells of copper and ten of zinc.

Mr. PREECE (after referring to the paper) said that the writer mentioned positive and negative currents of equal strength and duration.

A note on Mr. Latimer Clark's "*Method of Measuring Differences of Electric Potential*" was laid before the Society by Professor ADAMS. The author said that it would be better to avoid reading the paper at the present meeting, as it contained numerous mathematical equations which could not be followed by the hearers. It simply suggested a slight alteration of Mr. Latimer Clark's method of measuring differences of potential, and the object was to economise the use of instruments. In order to compare the electromotive forces of two batteries, M. Poggendorf joins them up in such a way that the current from the weaker battery may be balanced by an equal and opposite branch current from the stronger battery. We may regard it as a method of determining in what length of line of a given simple circuit the fall of potential is equal to the electromotive force of the weaker battery. Thus, if C be the electromotive force of the stronger battery, $R+\rho$ the total resistance of a simple circuit, and Q the strength of the current, then, by Ohm's law, $C=Q(R+\rho)$. Now, if the poles of another battery, whose electromotive force is E, be joined up, as in Poggendorf's method, to two points of the first circuit between which the fall of potential is equal to E_1, then no current will flow from this second battery, and the current in the simple circuit in the first battery will not be disturbed. If we regard ρ as the resistance between these two points, then, applying Kirchhoff's laws to the secondary circuit, we get $E_1=Q\rho$. Hence we obtain the result arrived at by Poggendorf that—

$$\frac{E_1}{C}=\frac{\rho}{R+\rho}\ (d)$$

Mr. Latimer Clark employs this method, and greatly extends its use by determining in what length of line of the same simple circuit the fall of potential is equal to the electromotive force of a standard cell of known value. And the electromotive forces of the standard cell and another battery are proportional to the resistances between the points where their poles are joined up to the circuit of the first battery so that no current may pass through them. The standard cell and the battery to be compared with it may be joined up at the same time to the principal circuit of the stronger battery, since their circuits are completely balanced. In the same way it is clear that any number of separate batteries may be joined up to the same principal circuit at the same time, and their electromotive forces compared directly with one another and with the standard. The mathematical work of the paper is a consideration of how far a current in one of these secondary circuits will affect the other secondary circuits which we may suppose to be already balanced. From this investigation it appears, as might have been expected, that a current through any secondary circuit will produce a current through the constant cell. Hence, to compare the electromotive forces of any number of separate secondary circuits it is only necessary to have one galvanometer, and this should be placed in the circuit of the standard cell. The important practical result which we arrive at by considering these equations is that, in order to compare the electromotive force of any battery with the standard cell, it is only necessary to employ one galvanometer, and that if this galvanometer be joined up with the standard cell the electromotive force of one or of any number of separate batteries may be found by shifting the point of contact of each one of them until no current is produced through the galvanometer when the contact is made or broken.

Mr. LATIMER CLARK said that he thought that Prof. Adams had made a very useful and practical simplification of the old method of measuring potential, and one which he thought would be more and more employed the more it was known. It was a most con-

venient method, and ought to be used more generally than it had been used. He very much liked the suggestion which Prof. Adams had made that we could measure resistance by reversing the operation and rising the electrometer, as well as being able to measure potential. He hoped that Prof. Adams would give them some better idea as to how far practically they could depend upon the use of one galvanometer only, that is to say, whether they could measure potentials to a hundredth, or a two-hundredth, or a five-hundredth of the whole, with an ordinary practical arrangement, and an ordinary practical galvanometer. No doubt his calculations would enable him to give them some idea as to within what percentage they might rely with the smaller battery. Of course it was impossible for him (Mr. Clark), in conducting the experiments, not to see the relation of movement between the two galvanometers. Without having the ability to calculate the relation, it being a very complex matter, he judged merely from his own ideas that it would not be sensitive enough, but the idea occurred to him that it might have been so used, inasmuch as he found it constantly necessary to watch the two galvanometers and to keep them adjusted. He might mention that he had also used the instrument for obtaining an exact and known degree of potential in small condensers. It was a very convenient measure of giving an exact unit measure in them. He had found it possible to divide the potential of a single cell of any ordinary battery, as a Daniell's battery, into a million equal parts. That was done by using a Thomson's galvanometer. He would not say that he could rely upon such measurments, but he could certainly indicate a difference of a millionth part. Measurements of a thousandth part could be read and determined with very great accuracy. If Prof. Adams would tell them whether they could come within one-tenth per cent, or one per cent, of the real measure it would be a matter of practical utility.

Professor ADAMS replied that his formulæ were not sufficiently reduced to members to enable him to give any percentage. He had the relation between the two branch resistances in the form of an equation, but he had no numbers attached for any particular arrangement of battery. He had only a general expression for the resistances of the battery. But he thought that the practical way of determining the question would be to make use of two galvanometers, and then to note accurately the deflections of both at the same instant. He should rather try the experimental method for determining the sensibility and see whether it agreed with the mathematical result. By noting the deflections produced in the two galvanometers by shifting the point of connection through a given resistance the result would be at once obtained.

Mr. LATIMER CLARK said that his impression from what he remembered was that they would be able to measure accurately to the extent of about a thousandth part of a Daniell cell, with a resistance of 40 ohms in the wire.

The CHAIRMAN said that one point which struck him as of special importance in the paper was that they would be able to compare not only two but any number of batteries at the same time with the use of a single galvanometer. It must be inconvenient in most laboratories to employ many galvanometers at once for such a purpose; and he could quite well imagine cases where it might be desirable to compare simultaneously several electromotive forces. It struck him, on a general view of the subject, that the comparison would be very accurate when the electromotive forces to be compared were nearly equal, but that the sensitiveness of the arrangement would be considerably diminished if they differed very much.

Mr. LATIMER CLARK: Undoubtedly.

Professor ADAMS said that there was no doubt that the arrangement would be most sensitive when the resistances were nearly equal; but unless the difference was very great the method would give a very close approximation to the result which would be obtained by inserting a second galvanometer. Of course if one resistance was very small compared to the other the test would not be very good.

A paper on "*Condensers in Connection with Duplex Telegraphy*," by Mr. R. S. CULLEY, was read by the Secretary. The following is an abstract:—It has been found that in using condensers with duplex telegraphy the alteration of the capacity of the condenser sometimes made little or no difference in the working of the circuit. This was pointed out to the author by Mr. Stearns, with his own conjectures as to the cause. He remarked, "Mr. Marson told me that it seemed to matter very little whether 2 or 5 micro-farads were used on some circuits. This sorely puzzled me. Mr. Carson, at the Anglo-American, made the same report. I tried to test the same question at Brighton when using one of your condensers, and again when trying to work Hughes's duplex, between G. P. O. and Southampton some days ago. My own observations confirm Mr. Marson's." Mr. Stearns attributed the cause to an inductive action between plate and plate in the condenser, making the aggregate action complicated and unsatisfactory. In order to test this view of the question a numerous and careful series of experiments was made for the author by Mr. Andrew Bell at the Gloucester Road Stores. The introduction of duplex telegraphy has necessitated the employment of a number of approximately accurate condensers, and these have been manufactured almost entirely under the superintendence of Mr. Bell. The condensers in use for duplex working are usually of a capacity of nearly 5 micro-farads, and are arranged in a series or five plates, so that the capacity may be increased or decreased by the simple alteration of the plug commutator. The five plates are of the following capacities:—

1 = 2 micro-farads.
2 = 1 ,,
3 = 0·5 ,,
4 = 0·25 ,,
5 = 0·125 ,,

The material employed for the "inductive" surface is tin-foil, the dielectric being paper steeped in paraffin wax. The paper is known as "cream-wove bank post," and is cut to the size of 8·55 × 7·3 inches (Fig. 4). The tin-foil is of the thickness of 0·00097 inch, and is of the size of 7¼ × 6 inches. The corners are cut off 2·4 inches, as seen in the sketch (Fig. 5).

Two sets of foils are used, the one for "line" or the "inductive surface," the other for "earth." The foils in the latter exceed the former by one. As many foils as are required to make a "plate" are placed together, and the uncut corners are soldered together so as to form a "book." Small tinned copper lugs, with a wire to connect to the terminal or shed, are soldered to as many foils as are needed for the plate. In "building" a plate the foils are placed in an inverted order on the surface plate, which is of highly polished metal. It is heated from underneath by a Bunsen gas burner, and is provided with a channel round it for carrying off the surplus paraffin. The foils are turned over one by one from both sides alternately. During the process a battery and galvanometer are kept in circuit between the two sets of foils to discover faulty papers. Between each foil and that next to it are placed two sheets of paper. The paper, which has been previously well dried, is first placed on the surface plate. The papers and foils are carefully covered with melted paraffin by means of a camel's-hair brush, as they are laid in position. The completed plate has an earth foil at each end, and upon

being finished is placed between two warm metal plates, and pressed with about 8 cwts., so that the surplus paraffin is brushed out, and the plate consolidated. The plate when cold is adjusted by the "standard." The inductive dimensions of foil are equal to about 9·86 square feet to 1 micro-farad capacity. Some plates require as much as one-tenth additional

FIG. 4.

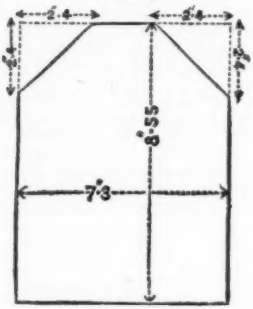
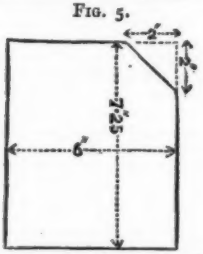
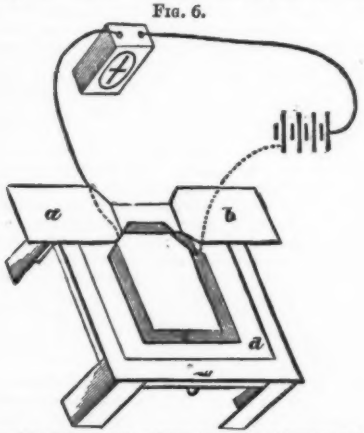


FIG. 5.



surface to give the micro-farad capacity. The first series of experiments was made with three separate plates, each of the capacity of about 1 micro-farad, properly insulated, so that they could be tested

FIG. 6.



a, Line-foil; *b*, Earth-foil; *c*, Paper-insulator; *d*, Surface-plate, heated below by a Bunsen gas-burner.

separately or in any combination by superposing them. The tests were taken with a battery of four cells partly shunted in order to give a readable deflection, and the charger and discharger were measured by an ordinary Thomson reflecting galvanometer.

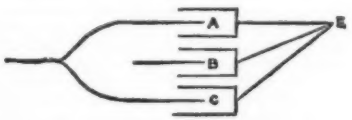
The following gives the results arranged in a tabulated form :—

MEASUREMENT OF CONDENSER PLATES DETACHED AND SUPERPOSED.

Capacity of the Three Plates used, about 1 Micro-farad each.

Plates or Combination and Position of Line and Earth Connections.	Charge. Mean Degrees.	Immediate Discharge on a Short Contact. Mean Degrees.	Immediate Discharge on Contact giving full Saturation. Mean Degrees.	Time.	No.
Plate A, detached	100·5	96·5	100	3″	1
„ B, „	97	93·5	97	„	
„ C, „	100·5	95·5	100	„	
Sum	298	285·5	297		
Plates A, B, and C, superposed, as in box ..	291·4	282·4	293·7	5″	2
Plates A & C, line connection of B disconnected (Fig. 4).	197	191	197·6	4″	3
Plates A & C, line and earth of B disconnected	197	191·6	197·6	4″	4
Plate B, lines A & C disconnected	93	93·3	96	3″	5
Plate B, lines and earths A and C disconnected	94	93·3	96	3″	6

FIG. 7.



Hence it will be seen that the total reading from the three plates differed but little from the sum of the readings of the three plates taken separately. There appeared to be no difference when the line only of one plate (the middle one) and when the line and earth were disconnected. The sum of the two plates gave 197·5°, the two plates taken together giving 197°, and 197° when the plate B was disconnected. This shows that the disconnection of B had no effect upon the discharges obtained from the plates on each side of it. Taking also the discharges obtained from B alone, with plate A on one side of it and plate C on the other, there is no difference to warrant a supposition that there was an inductive influence at work tending to alter the capacity of the condensers. In order to assimilate these experiments as much as possible to the ordinary duplex working, some were taken with split strong currents, to obtain, as nearly as possible, the discharges resulting from duplex working. They are as in table at top of next column.

From the table it will be seen how closely the various results agree. The very slight difference in one or two cases must be attributable to a little longer or shorter duration of the momentary contacts as used in signalling. A further experiment was tried, which was somewhat conclusive. The three plates, A, B, and C, were superposed, B being, as in each case, in the middle. A and C were charged in the usual manner, but there were no signs of any induced charge in B. The second series of experiments was taken with a

MEASUREMENT OF CONDENSERS.

Discharges measured. Charge split through 10,000 *ohms.*

Plates or Combinations, and Portion of Line and Earth Connections.	No. of Charging Cells.	Immediate Discharge on a Short Contact. Separate Measurements.	Mean.
Plate A, detached ..	50	96, 97, 99, 97	96·7
„ B, „ ..	„	94, 94, 93, 93	93·5
„ C, „ ..	„	94, 95, 95, 94	94·5
		Sum	284·7
Plates A, B, and C, superposed	„	285, 282, 283, 284	283·5
„ A and C, line of B disconnected	„	192, 191, 191, 192	191·5
Plate B, line of A and C disconnected ..	„	94, 93, 94, 94	93·7
Plate A, detached ..	100	96, 97, 96, 97	96·5
„ B, „ ..	„	93, 94, 93, 93	93·7
„ C, „ ..	„	93, 94, 94, 94	93·7
		Sum	283·9
Plates A, B, and C, superposed	„	281, 282, 281, 282	281·5
„ A and C, line of B disconnected	„	190, 190, 189, 190	189·7
Plate B, line of A and C disconnected ..	„	93, 93, 94, 94	93·5

finished condenser, the first series having been made with loose plates. To enable the charging current to be properly split, the connections of a double-current key were altered to suit the purpose, so that short contacts made with it should resemble actual duplex working as nearly as possible. Repeated readings scarcely varied a single division. The first measurements were made with a potential of only 4 cells, and the plates were allowed to charge fully. Further tests were taken with 50 cells split through a large resistance (10,000 ohms), the shunt being altered to give the same readings for the plates. Deflections were taken from the plates both separately and in combination, and the results obtained in both cases agree one with another, showing satisfactorily that there was no induction from plate to plate. The following statement gives some particulars of the duplex circuits in which condensers are used.

CAPACITY OF CONDENSERS ON DUPLEX CIRCUITS.

From		Length in Miles.	Gauge.	Capacity of Condensers in Use. From Microfarads.	To Microfarads.
Telegraph Street	Birmingham	130	10	2·75	—
	Do.	130	10	2·40	—
	Manchester	192	8	3·00	3·00
	Do.	208	8	2·75	3·00
	Edinburgh	400	8	3·00	—
	Do.	400	8	3·48	—
	Liverpool ..	205	8	2·75	2·00
	Do.	205	8	3·24	3·00
	Dublin ..	370	4	2·50 3·00	10·75
	Bristol ..	120	8	1·00	—
Edinburgh	Liverpool ..	227	8	1·00	—
	Dundee ..	51	8	0·50	0·50
Glasgow	Inverness ..	210	8	2·75	4·00
		2848		34·12	

Mr. LATIMER CLARK said that he should very much like to hear what the electrostatic capacity was at the Dublin end and the London end of the circuit, and also, by comparison, what was the ordinary electrostatic capacity of condensers used for land lines, without submarine cables in circuit. He should expect to find it very much larger at the Dublin end than at the other end. The paper only confirmed what might have been very well expected from theory. It would have been most surprising if there had been any induction taking place between two plates of tin-foil which were separated by a third plate which was in connection with the earth. At the same time it was satisfactory to find this view confirmed by a series of carefully conducted experiments, and to know that the condensers might be relied on as true and good measures of electrical capacity. There seemed to be some difficulty in getting a permanent condenser, and, as far as he was aware, it had not been accomplished. He had tried mica instead of paper, and shellac, paraffin, and various compounds of gutta-percha, but nothing had been quite permanent. In 1862 he made three condensers very carefully, of shellac and mica, and they were adjusted very carefully together. They were used in India and various parts of the globe, and remained quite coincident until about three years ago. They then began to change in their relative capacities, and at the present time one was 6 or 7 per cent below the others, and the one of the largest capacity was the most accurate. With gutta-percha and paraffin the changes were much greater. A permanent condenser which would retain a fixed measure of electricity was a great desideratum.

Mr. PHILLIPS asked whether the paper used by Mr. Culley was rag-paper. In some experiments which he tried some years ago he found that a very common kind of straw-paper gave vastly the best results.

In reply to this enquiry Mr. PREECE said that, as far as he knew, it was paper made in the ordinary way. It was known by the name of "bank-post." Mr. Latimer Clark, after examining a specimen, pronounced it to be rag-paper.

Major MALCOLM enquired whether the condensers would retain their charge as long as an hour.

Mr. PREECE said that he could not tell the time that they would hold their charge. They were only made of approximate capacity, and they were not of the materials usually employed in the best condensers for cable-work. The object was not to hold the charge for any length of time, or they would interfere with the true electric balance of the duplex circuit, and they were used only for that work. For cable-testing, or anything in that department, they used a condenser of an entirely different kind, and one which would hold its charge for a definite period. Mr. Clark had asked a question about the capacity of the different circuits. The average seemed to be about 3 microfarads, taking the London and Edinburgh circuit of 400 miles. The two circuits varied a little. On the London and Dublin circuit, which was not quite the same length, the capacity from London was 3 microfarads, and from Dublin 11. The shortest was from Edinburgh to Dundee, and the capacity was half a microfarad. All the others seemed about the same, and had almost the same capacity at each end.

Mr. CLARK asked whether any experiments had been made in the use of distilled water condensers.

Mr. PREECE: Not that I am aware of. We have used ozokerit instead of paraffin.

The CHAIRMAN expressed the thanks of the Society to the authors of the papers, and recommended for imitation the example of Mr. Culley in placing on record, and making known for everyone's benefit, results which he had obtained in the course of his official investigations, and which might otherwise have been buried in the records of the Post-Office.

A meeting of this Society was held on the 25th ult. The chair was taken by Mr. LATIMER CLARK.

The Chairman announced that the new library room had been fitted up ready for the reception of books, and the Council hoped to commence shortly to furnish it with books.

A brief communication by Mr. W. H. Preece, on "*Earth Currents in Snow*," was read to the meeting. It described some observations which were made at Brighton, on the 10th of March, by Mr. G. Field. The writer regarded these observations as furnishing direct evidence that, in this instance at least, the so-called "earth current" was due to atmospheric electricity.

A letter from Mr. Graves, of Valentia, was then read. It related to the covering of submarine cables, and called attention to an accompanying specimen of a cable which had been submerged seven and three quarter years. The piece of cable was passed round for inspection by the audience.

The thanks of the meeting were voted to Mr. Preece and Mr. Graves.

A paper on "*The Decay and Preservation of Timber for Telegraph Purposes*" was read by Mr. W. Langdon.

Mr. Golston, Mr. Bell, Mr. Richerwood, and Mr. von Treuenfeld made some remarks on the subject.

The discussion was then adjourned.

A detailed report of the paper and discussion will be given in our issue of the 15th inst.

The following papers were promised for the next meeting:—"*On the Change of Resistance of High Tension Fuses at the Moment of Firing*," by Major Malcolm; "*Notes on Electric Fuses*," by Professor Abel.

The meeting fixed for Wednesday, April 8th, has been postponed, on account of that day being Easter Wednesday.

Electrical Science in English and Foreign Journals.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Vol. lxxviii., No. 9.

On a Method of Producing Certain Induction Currents.—By M. A. Gaiffe.—This paper gives the results of fifteen experiments which M. Gaiffe carried out to investigate the cause of certain induction phenomena noticed when testing an induction apparatus used in the National Assembly to light the gas of the assembly room. The experiments are not yet complete, and at the end of his paper the author says "I continue these researches; but before giving expression to any explanation which these experiments seem to lead to, I shall lay before the Academy some fresh experiments upon the same subject." The question is an interesting one, and we hope when M. Gaiffe has completed his enquiry to give a short abstract of his papers in this Journal.

On the Influence of Albuminous Substances on Electro-Capillary Phenomena.—M. Onimus.—When two heterogeneous liquids are separated by an organic membrane or by a capillary space, as M. Becquerel has shown, they give rise to an electric current which is capable of producing chemical and mechanical effects. In many cases he noticed that the interposition of albuminous substances (white of egg, albumen of the blood) between two liquids would cause the same electro-chemical actions. In a tube, shaped U, sufficient albumen to fill up the bottom was first poured in; then, on each side, the liquids which serve to react on each other were gently added so as to prevent an abrupt mixing with the albumen. After awhile the solutions met in the bed of albumen, when the double decompositions indicated by M. Becquerel took place. Crystals formed by such decompositions always form a mass more or less granulated, and do not take the form of stalactites, which they assume when organic films are used. In separating by a bed of albumen some phosphate of soda, and some nitrate of lime or some chloride of calcium, phosphate of chalk was obtained on the side in which phosphate of soda had been put. One may conclude from these facts the practical information that it is perhaps more useful to administer these salts separately than to cause the phosphates of lime to be operated on directly, since the production of this salt is easily made in the organism. Further, although neither the chloride of calcium nor the phosphate of soda cause the albumen to coagulate, yet coagulation is formed very manifestly, like a series of films, in the region where the double decompositions take place. It may be said in general that there is always a coagulation more or less extended each time that any electro-molecular currents are generated, even when the liquids employed do not directly produce it. This coagulation is probably due to the currents themselves, for it only takes place on the side which may be termed the positive pole. At the same time, and especially when the coagulation hinders the liquids from freely communicating, differences of potential in the currents have been occasionally observed. *Students should read "Electro-Capillary Constant Current Piles," and "Memoirs on Electro-Capillary Batteries and Actions," by M. Becquerel, contained in vol. i. of this Journal, pages 108 and 160 respectively.*

Les Mondes. Vol. xxxiii., No. 8, Feb. 19, 1874.

M. Clamond's Thermo-Electric Pile.—This pile would now seem to be a great reality. Three models have been prepared—(1) a tension pile equivalent to two of Bunsen's elements made of small bars; (2) a tension pile equal to four of Bunsen's elements made of small bars; (3) a quantity pile equal to four of Bunsen's elements of large bars. It may be said that the third pile can be used for the purposes of electrotyping, for of itself it will render it perfectly viable. It expends 150 litres of gas per hour, and is capable of depositing a kilogramme of copper for the price of 2 francs 50 centimes. M. Clamond has ingeniously added to all his piles a Girond regulator, which secures an almost constant heat, and an absolutely constant current. On comparing this account with the invention of Messrs. Mure and Clamond (see vol. i., page 11 of this Journal) it is apparent that a great improvement has been effected in the pile as regards the cost of the production of a kilogrm. of copper, the preservation of an almost constant heat, and, most important of all, the generating an absolutely constant current of electricity.

No. 10. March 5, 1874.

The Action of Light upon the Electrical Resistance of Selenium.—Copy of an article by Lieut. Sale, R.E., appearing in the *Philosophical Magazine* of March, 1874, and in which he *further* investigates by experiments some of the laws respecting the action of light upon selenium observed by Mr. Willoughby Smith.

Boston Journal of Chemistry. Vol. viii., No. 7, January, 1874.

The Disadvantage of Different Thermometric Scales.—We have no doubt that our readers have sometimes been vexed at having to change Centigrade temperatures to Fahrenheit, or *vice versa*, and it is no unusual thing to find one taken for the other by popular writers. The Centigrade and Réaumur scales are even more likely to be confounded, on account of their general similarity. A mistake of this kind was recently the chief cause of a patient's death in a hospital in Vienna. A bath was ordered at a tem-

perature of 40° C. (104° F.), but the attendant heated it up to 40° R. (120° F.), scalding the patient so severely that death was the result. If our German friends are going to adhere to their Réaumur scale they should not adopt the Centigrade; or if they adopt the latter, the former should be altogether abolished.

Scientific American, Vol. xxx., No. 2, January 10, 1874.

Electrical Gas Regulator.—Mr. P. Munzinger, gas engineer of the Pascal Iron Works, Philadelphia, Pa., has devised a system whereby the flow of gas from the works into the mains can be regulated and controlled automatically by establishing electrical connections between any point of the gas main and the works where the gas is manufactured.

No. 9, February 28, 1874.

D. D. S. writes to suggest that lightning rods be made in the form of an elongated oval, about 6 feet wide, so that the conductor would present the appearance of two rods, side by side, joined at the top; and they would also be joined under ground. He thinks that this arrangement will give better protection to a building, from the better ground communication it would afford.

Repertorium für Experimental Physik. Band 9, Heft 6.

On the Lichtenberg Figures, a Century after their Discovery.—M. Moritz Kuhn.—An instructive historical sketch. The author thinks it still doubtful whether the air and gas-particles in formation of the figures are moved, in the case of the positive figure, from the point to the plate (Reitlinger), or from the plate to the point (Bezold), and *vice versa* in the negative figure. But the researches of these two physicists have made it extremely probable (and it is an important advance) that movements of air and gas-particles are the cause of the differences of form of electrical dust figures. And as scarcely any doubt remains that electricity as well as heat depends on phenomena of motion, the hope expressed by Lichtenberg that the various figures obtained would throw light on the nature of electricity is brought nearer fulfilment.

Researches on Secondary Currents and their Applications.—M. Planté.—A *resumé*, with illustrations.

On the Choice of a Galvanic Current Unit.—M. Kohlrausch.—(See *Pogg. Ann.*)

Preliminary Notice on the Application of Secondary or Polarisation Batteries to Electro-magnetic Motors.—M. Jacobi.—Reserved for separate note.

On a New Electric Machine on Holtz's Principle.—(See *Telegraphic Journal*, vol. ii., p. 62.)

Electrification by Friction and the Lichtenberg Figures.—M. Douliot.—A plate of ebonite, if dry, is rendered electric by the least shock, by friction with a piece of paper or with a hair pencil. This can be well shown to an audience. The plate is first thoroughly dried over a spirit lamp, then written on with a piece of wood, or a pencil or metallic point. No trace is visible. The ordinary mixture of sulphur and red-lead is then sprinkled, and the letters come out very distinctly in red. A well-dried glass plate, rubbed with a ball of cotton, being written on, then strewn with the powder, the sulphur is held, and the trace is yellow.

Journal de Physique. Vol. iii., No. 25.

On the Principle of Volta.—Prof. Righi.—Reserved for separate note.

Physico-Chemical Researches on Gases and Liquids Condensed by Porous Carbon.—M. Melsens.

No. 26.

Electro-Capillary Experiments.—M. Lippmann.—The capillary constant at the surface of separation of two liquids is function of the electromotive force of polarisation at this surface; and the electromotive force is function of the variation of air at this surface.

Construction of a Scale of Electric Resistance.—M. Crova.

First Report of the Committee of the British Association Charged with the Choice and Nomenclature of Dynamic and Electric Units.

Archives des Sciences Physiques et Naturelles. Vol. xlix. No. 194.

Note on the Supposed Connection Between Solar Eclipses and Terrestrial Magnetism.—Prof. Denza.—Careful observations of the declination needle were made at three Italian stations, D'Aosta, Moncalieri, and Florence, for nine consecutive days, before, during, and after the solar eclipse of 26th May last. The deductions made from previous eclipses (which the author details) were entirely confirmed. The variations of magnetic declination took place on the day of the eclipse as on the days preceding and following it, and, in general, as on every other normal day. "A connection between the two orders of cosmic facts in question is by no means demonstrated by the observations hitherto made."

Philosophical Magazine, Vol. xlvii., No. 308.

On the Relationship of the Magnetic Metals.—Prof. Barrett.—Their similarity in physical and chemical properties is shown from the following table:—

Substance.	Density. Water = 1.	Atomic weight H = 1.	Specific heat. Water = 1.	Atomic heat.	Dilatation. By heat.	Dilatation. By strain.	Conductivity. For heat. Silver = 1.	Conductivity. For sound. Air = 1.	Tenacity and melting-point.
Iron ..	7·8	56·0	0·1138	6·38	0·0926	0·0387	0·168	15·3	Very high.
Nickel	8·3	58·5	0·1091	6·33	0·0899	0·0394	0·131	14·9	,,
Cobalt	8·5	58·5	0·1070	6·26	0·0981	0·0436	0·172	14·2	,,

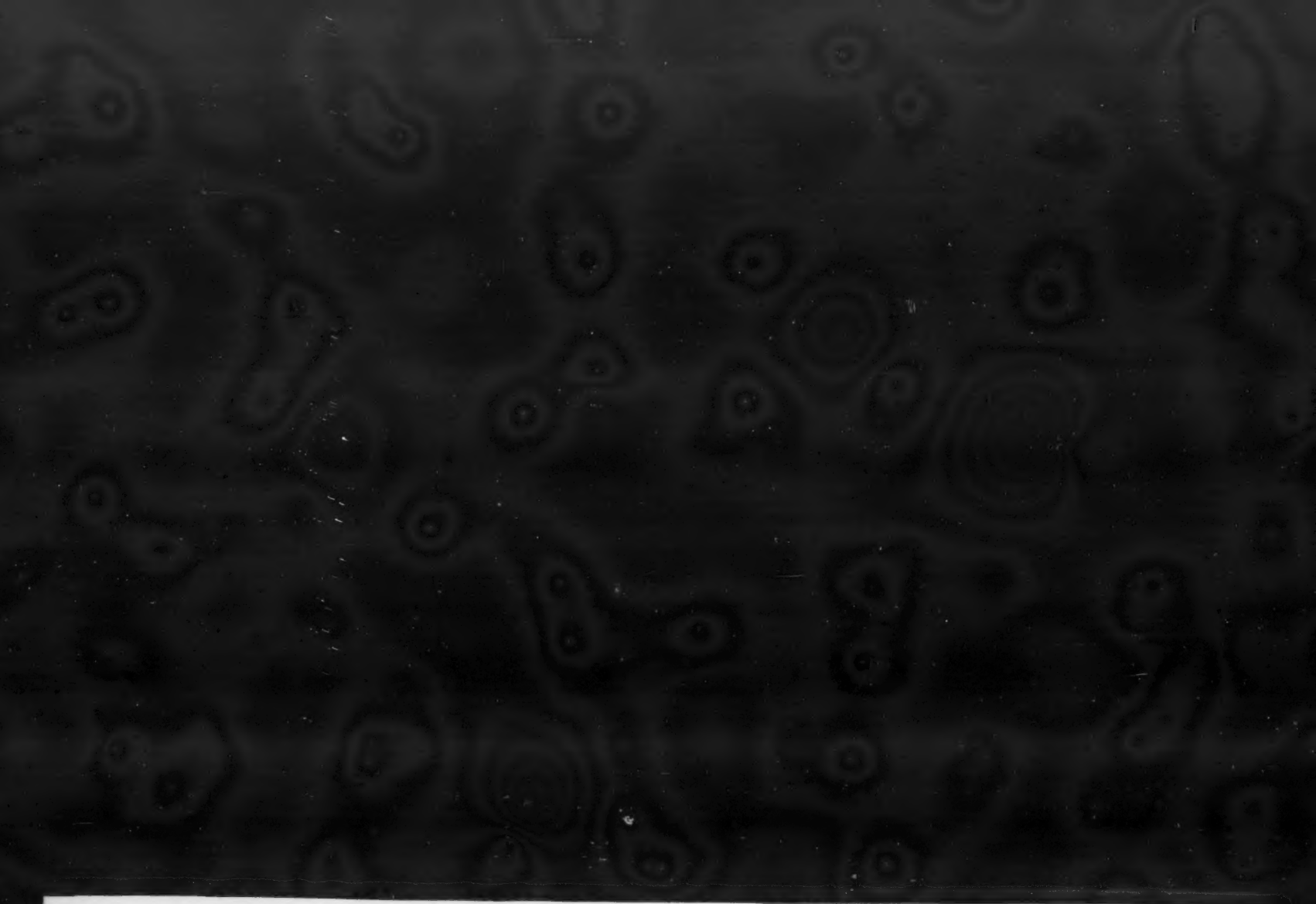
On a New Relationship Between Heat and Static Electricity.—Mr. A. W. Bickerton.—The author thinks the relationship, pointed out by Dr. Guthrie, may be explained by the assumption that currents of air, passing over an electrified body, carry off its electricity. Several experiments are adduced. Cold air discharged against a Peltier's electrometer does not take away its electricity, but hot air does. Again, in a glass jar were inserted a platinum spiral, at the upper part, a thermometer, with bulb a little below spiral, and a brass knob (connected with electroscope) 2 inches below the bulb. The spiral being kept white-hot, the thermometer showed a rise of 1° when the ball was not electrified, and 5° when it was, indicating a downward current of hot air on the ball. Smoke being introduced, there was a downward rush of it, from spiral to ball, on electrifying the latter. Again, the heated wire has no power to discharge (the ball) through rock salt. An induction current gives a much larger spark when the electrodes are heated; and it was proved that this lengthening could not be due to rarefaction of the air. From experiments by Faraday, Dr. Guthrie, and himself, the author concludes—(1) that at low temperatures −electricity is taken away most easily; at high temperatures +electricity; while at certain temperatures both electricities are carried off with equal facility; (2) that high tension electricity can be conveyed away at low temperatures, and as the tension gets lower and lower, it requires the air to be of higher and higher temperatures to carry it off.

On the Differential Galvanometer.—Mr. O. Heaviside.

No. 309.

Disintegration of the Electrodes in the Galvanic Arc of Light.—M. Herwig.—A translation.

A Theory of the Source of Terrestrial Magnetism.—Prof. Challis.—This theory attributes magnetic streams to impulses given to the ether by the earth's atoms in



motion. The author first seeks to show that the earth's motion of translation can have little or no magnetic effect. Then, as to rotation, the theory is, briefly, as follows:—While there is any relative *circular* motion between the ether and the atoms, the latter will continually impel the ether, till the relative motion is reduced to zero. Ultimately, therefore, the circular motion of the ether, within the earth, is the same as that of the atoms by which it is impressed. By reason of centrifugal force the circular motion will produce in the external ether an amount of circular motion decreasing with distance from the axis of revolution. Now, the earth's rotatory motion will tend to draw the ether from the axis equally in all directions in any given transverse plane; and the external ether will rush in at the pole parts, to supply any vacancy arising from centrifugal force. If the solid and fluid parts of the earth were symmetrical with respect to the equatorial plane, these tendencies would just counteract each other, the influx at each pole would be stopped, and no currents, other than the circular, would be generated. But, the case being otherwise, there is a differential action, whereby streams are produced, which, as circulating, are permanent relatively to the earth. The currents being always towards the positions of greatest atom-density, they will flow out of the northern parts (in which land preponderates), and, after circulating, enter into the southern parts. And it is in accordance with the theory that in the Northern Hemisphere there are two positions of maximum intensity; one in a high latitude of the North American Continent, the other a little north of the Asiatic. There is not the same reason for two maxima in the Southern Hemisphere; and, in fact, observation shows that, if there be two, they cannot be far apart. Hence, too, the theory accounts for the circumstance that the magnetic intensity is greatest near the South Pole; for the total influx is necessarily equal to the total efflux; and the influx is intensified in that quarter either because there is but one position of maximum intensity, or, if there be two, because they are near each other. The author finds further support for this theory in certain phenomena of aberration, as showing the reality of an impulsive action between atoms and ether.

On Wheatstone's Bridge.—Mr. R. S. Brough.

On the Electromotive and Thermo-electric Forces of some Metallic Alloys in Contact with Copper.—Mr. Sundell.—A translation.

On a simple Condensing Collector for Frictional Electric Machines.—Mr. S. Roberts.—For a small machine the author takes a glass tube 13 inches long, hermetically sealed at one end. A fine copper wire is inserted, and a piece of paper, 2¼ inches broad, is wrapped four or five times round the closed end. The open end, with a little wire projecting, is applied to the prime conductor, and the outer coating must be in good electric connection with a metallic ball by means of a similar wire twisted once round the paper. In this way brilliant zigzag sparks were obtained 4½ inches in length. Other modifications are described.

On the Molecular Changes that Accompany the Magnetisation of Iron, Nickel, and Cobalt.—Prof. Barrett.—The author extends some of the observations made upon iron to nickel and cobalt. One fact stated is that the sound, on magnetising cobalt, is the most powerful. Near the temperature at which a cooling iron wire resumes its magnetic state a profound change occurs in its physical condition. A momentary dilatation of the iron takes place; its thermo-electric position is reversed, a sound is emitted, and a sudden re-heating or "after glow" is observed to diffuse itself thoughout the metal just before it ceases to be incandescent. Its electric and thermal resistance, too, appears to be changed.

On an Air Battery.—Dr. Gladstone and Mr. Tribe.—(See TELEGRAPHIC JOURNAL, vol. i., p. 141.)

No. 310.

On Wheatstone's Bridge.—Mr. O. Heaviside.

On Galvanic Polarisation in Liquids Free from Gas.—Dr. Helmholtz.—A translation. (See TELEGRAPHIC JOURNAL, vol. ii., p. 79.)

On the Discharge of Electrified Conductors.—M. Moutier.—A translation. (See TELEGRAPHIC JOURNAL, vol. ii., p. 78.)

City and Commercial Notes.

The Secretary of the India-Rubber, Gutta-Percha, and Telegraph Works Co. (Limited) informs us that the Company have received news of the completion of the direct submarine cable between Marseilles and Barcelona, laid by the steamship *Dacia*. The completion of this new cable is a matter for congratulation, as cable communication is thereby re-opened between Spain and the rest of Europe hitherto interrupted by the destruction of the land lines in the districts affected by the civil war. The cable will be opened for public traffic this day (April 1).

The Telegraphic Construction and Maintenance Company (Limited) has taken steps for extending the system of submarine telegraphs along the west coast of South America, where a valuable traffic awaits its completion. In furtherance of this object, an exclusive concession has been secured from the Peruvian Government, and within eighteen months the directors hope to have a cable laid connecting Peru with Panama.

The report of the Cuba Submarine Telegraph Company (Limited) shows that the gross receipts for the half-year, including the balance from last year's accounts, amount to £6349, and expenses to £2065, leaving a balance of £4283, which, compared with the previous year, is a considerable falling off, the cable having ceased to work at the end of October. The report further mentions that it is feared the heavy expenses connected with the repair of the cable will involve the company in questions with the West India Company, at whose suggestion the sum of £3000 was subscribed by this company towards the purchase and fitting out of the s.s. Suffolk, and a further sum of £4000 was laid aside towards her maintenance, on which outlay no return has been received. The directors therefore recommend no interim dividend; but propose that the above balance of £4283 shall be carried to the reserve fund.

At a meeting of the directors of the Globe Telegraph and Trust Company (Limited), held on the 25th ult., it was resolved that interim dividends be declared of 3s. per share on the preference shares of the company for the quarter ending 18th April, 1874, and of 5s. per share on the ordinary shares, being at the rate of 5 per cent per annum for the six months ending the same date, and that the warrants be made payable on the 18th April. The transfer books of the company will be closed from the 13th to the 18th April, both days inclusive.

The Eastern Telegraph Company announce the closing of their books from the 7th to the 14th April, for the payment of the usual interim dividend of 2s. 6d. per share for the quarter ending 31st December.

The directors of the Eastern Extension, Australasia, and China Telegraph Company (Limited) have resolved to recommend a dividend of 4s. per share, free of income-tax, making, with previous distributions, a total of 6¼ per cent for the year ending December 31, 1873. The balance carried forward is £27,137.

The Anglo-American Telegraph Company (Limited) announce thai their register of transfers will be closed from the 1st to the 7th inst., both days inclusive, preparatory to the payment of an interim dividend of 1¼ per cent.

The Report of the Directors of the Direct United States Cable Company (Limited), submitted at the general meeting, on the 31st ult. states:—"The account, which has been certified by the company's auditor, will show to the shareholders the financial position of the company up to the close of the past year. Since then the amount outstanding for calls in arrear has been reduced to £11,889. The chief feature for notice is the manufacture of the cable, and the directors would refer the shareholders to the report of the electrician for the highly satisfactory condition of its progress, and to the important facts that both the electrical power and mechanical strength are far in excess of the requirements of the contract. These results have been verified by the systematic application of tests more severe than any that have been applied during the construction of former cables. The directors have further to report the visit of the manager to Newfoundland, Nova Scotia, and the United States, and the selection by him of landing places in Newfoundland, Nova Scotia, and New Hampshire in the United States. Arrangements have been made for the acquisition of the necessary land at all those places, as recommended by Mr. Von Chauvin. The directors have much pleasure in stating that since the commencement of the current year, the manufacture of the cable has been rapidly advancing, the last returns showing that 1536 nautical miles have been completed. They have also to report the selection of a suitable site in Ireland for the shore end of the cable. On the 17th of February last the launch of the new cable steamer *Faraday*, built to the order of the contractors, was successfully effected, and the first cable that will be laid by her will be the cable of this company. In accordance with the terms of the contract, the *Faraday* will be moored off Messrs. Siemens's works at Woolwich for the reception of the cable on the 15th of April. The vessel, which is upwards of 5000 tons burden, will be fitted up with all the improvements which the contractors think likely to promote the security of the cable, and to assist in its being successfully and rapidly laid down."

TELEGRAPH SHARE LIST.

Amount per Share.	Name of Company.	Amount paid up.	Closing Quotations.
£		£	Mar. 31.
Stock	Anglo-American (Limited)	100	74—75
10	Brazilian Submarine..	9	3—2⅛ dis.
10	Cuba	All	7¼—7⅜
10	Direct Spanish	9	..—..
20	Direct United States Cable	17	5⅛—4¼ dis.
10	Eastern (Limited)	All	7⅞—8
..	Do., New	..	..—..
10	Eastern Extn. Australia and China	All	7⅞—7¾
10	Globe Telegraph and Trust	All	7—7¼
10	Do., 6 per cent Pref...	All	9—9¼
10	Great Northern	All	9¼—10
25	Indo-European	All	16—17
10	Mediterranean Extension (Limited)	All	4—4¼
10	Do., 8 per cent Pref...	All	11—12
10	Panama and South Pacific	2½	..—.. dis.
8	Reuter's..	All	11—11¼
Stock	Submarine	100	230—240
1	Do., Scrip	All	2—2¼
10	West India and Panama	All	5—5¼
10	Do., 10 per cent Pref.	All	9¼—9¾
20	Western and Brazilian (Limited) ..	All	11—12
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The Ashantees and the Telegraph.—A Correspondent, writing from Cape Coast Castle on the 20th February, says: "I suppose you heard that the Ashantees could not understand our telegraph, and so they, in imitation, carried a line of white cotton from tree to tree all along the road, passing it here and there through rags of white calico."

Patents.

1684. A. Jaynor, of Middlesex. *Improvements in Automatic Telegraph Transmitting Instruments.* Dated May 9, 1873.—The alteration required to adapt this invention to the existing telegraph instruments is to substitute the improved transmitting instrument in the place of the Morse or other key now in use. An important feature in this invention consists in its not requiring a skilled operator to transmit messages, it being simply necessary in using the improved transmitting instrument to press once only for each and every letter of the alphabet to spell the words of the message that it is desired to transmit.

1697. G. Haseltine, of London. (A communication from Baron Oldershausen, of Vienna). *An Improved Method of and Apparatus for Lighting and Extinguishing Gas-Burners.* Dated May 10, 1873.—Relates to a peculiar method of lighting and extinguishing gas-burners, by means of which one, several, or a multitude of house lamps, chandeliers, or street lamps can be simultaneously lighted. Effected by means of a galvano-mechanical apparatus, which, when set in action at the gas works or other convenient station, creates an electric current and sufficient heat for igniting a gas jet.

1713. A. M. Clark, of Middlesex. (A communication from G. Planté, of Paris). *Improved Apparatus for Lighting Lamps, Candles, and Similar Purposes.* Dated May 10, 1873.—This is an electric apparatus composed of a small secondary pair formed of two coiled lead strips dipping in a glass vessel containing acidulated water and enclosed in a box provided with clips for holding a platinum wire. The secondary pair is charged by a constant battery, and the apparatus is put in action by closing the circuit of the secondary pair, the platinum wire being thus heated sufficiently to ignite a lamp, candle, or other combustible matter contiguous thereto.

The Telegraph in China.—The Great Northern Telegraphic Company has recently established a line between Woosing and Shanghai. Twenty words are sent for a dollar. This is the first successful attempt to introduce the telegraph through the main portion of the empire, as previous efforts have been met with violent opposition from the people, who cut the wires and destroyed the poles.

It is stated that the Electrical Recorder, an invention for registering with unerring accuracy the number of passengers in omnibuses and tramways, will shortly be brought before the public. The invention is the joint work of Messrs. Wildman Whitehouse and Latimer Clark, and is one of the patents which the Electric Power Company was established to develope.—*Standard.*

To Correspondents.

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A.—We are obliged for your communication; you forgot, however to enclose your name and address.